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Do banks fuel climate change?

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Abstract

Do climate-oriented regulatory policies affect the flow of credit towards polluting corporations? We match loan-level data to firm-level greenhouse gas emissions to assess the impact of the Paris Agreement. We find that, following this agreement, European banks reallocated credit *away* from polluting firms. In the aftermath of President Trump's 2017 announcement that the United States was withdrawing from the Paris Agreement, lending by European banks to polluting firms in the United States decreased even further in relative terms. It follows that green regulatory initiatives in banking can have a significant impact combating climate change.

Keywords: Climate change; Paris Agreement; Trump; loan-level data; difference-in-differences;
JEL classification: E51, G28, H23

Non-technical summary

Climate change poses major risks to the global economy. Policymakers have recently started to recognise that climate change represents a major and pressing threat (Carney, 2015; ESRB, 2016). In this vein, the Paris Agreement, signed in December 2015, represents the first comprehensive climate deal that explicitly recognises the need to "make finance flows compatible with a pathway toward low greenhouse gas emissions and climate-resilient development". As a major provider of credit, the banking sector is, potentially, a key player in these efforts. At the same time, these green initiatives are happening in a period in which banks themselves face new risks, some of them also linked to climate change including physical and transition risks. As a result, lending away from polluting firms might be very costly.

In this paper we ask whether climate-oriented regulatory policies affect the flow of credit towards polluting corporations. We do this by examining two major climate change policy events to investigate whether European banks have started to change their lending behaviour in respect of polluting versus less polluting firms, possibly anticipating more stringent climate risk-related policies or more severe fluctuations in the asset values of polluting firms. To do this, we match an extensive loan-level dataset to detailed firm-level greenhouse gas emissions over time.

We find that, following the Paris Agreement, European banks reallocated credit away from polluting firms. Their loan share for more polluting firms decreased significantly – by about 3 percentage points – compared with that for less polluting firms, after the announcement of the Paris Agreement. In addition, European banks' loan share to more polluting US corporations decreased by around 2.4 percentage points, after President Trump's June 2017 decision not to uphold the Paris climate commitment. We contend that recent climate change initiatives, improved awareness of climate change-related risks, and the anticipation of more stringent policies are probably pushing banks out of climate-sensitive sectors towards greener business. We also show that banks which have lower credit quality and profits drive our main findings by reacting earlier and more decisively to climate policy initiatives.

We believe our work has important policy implications, as it underlines the pivotal role of banks in the implementation of significant climate change policies. It follows that green banking regulations could have an impact on ameliorating climate change and, as a consequence, central banks and banking authorities could play a significant role in shaping this debate.

1. Introduction

Climate change poses major risks to the global economy. It affects, for example, the availability of resources, influencing the price of energy and the value of companies. The Intergovernmental Panel on Climate Change (IPCC) has concluded that the level of emissions observed since the mid-twentieth century will probably lead to global warming reaching 1.5°C above pre-industrial levels between 2030 and 2052 (IPCC, 2018). This would cause long-lasting changes, increasing the likelihood of a severe, pervasive and irreversible impact on people and ecosystems. Rising temperatures and changes in weather conditions would hit most sectors – most directly agriculture, fisheries, energy, tourism and construction – with immediate consequences for national economies (EEA, 2012). The number of natural disasters worldwide and the value of (insured and uninsured) associated accompanying economic losses have risen over the last four decades (Charts 1 and 2).

Policymakers have, of late, started to recognise that climate change represents a major and pressing threat (Carney, 2015; ESRB, 2016). The Paris Agreement (COP21), signed in December 2015, represents a milestone: countries representing 97% of global greenhouse emissions agreed to respond to global warming by keeping global warming below 2°C. Furthermore, COP21 invites nations to publicly communicate their mid and long-term strategies for reducing gas emissions through Intended Nationally Determined Contributions (INDCs). COP21 represents the first comprehensive climate deal that explicitly recognises the need to "make finance flows compatible with a pathway toward low greenhouse gas emissions and climate-resilient development". This means pushing for a reorientation of capital allocation (Article 2.1(c)). It also increases peer pressure with regard to meeting global warming targets, as signatories are committed to rapidly reducing CO_2 emissions to achieve net zero emissions in the second half of the twenty-first century.[2,3]

As a major provider of credit, the banking sector is a key player in these efforts. The momentum established by COP21 enlarges the set of available investment opportunities to finance green projects and renewable energy. Indeed, investments in renewable energies have increased sharply in recent years (Chart 3) and are expected to grow enormously in terms of market share (IEA, 2015; International Renewable Energy Agency, 2016). This increase is driven by a growing

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[2] In particular, the EU has committed to reducing its greenhouse gas emissions by 40% by 2030, the United States by 26-28% by 2025, and China and India by 60-65% and 33-35% per unit of GDP respectively. The United States has, controversially, withdrawn from COP21. More information on the Paris Agreement is available at https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf.

[3] Central banks and national governments have supported climate change efforts. For instance, the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) seeks to support the transition to a low-carbon economy by raising awareness and pursuing efforts towards improving the pricing and management of climate change risks in the financial sector.

consensus in support of moving towards a low-carbon economy and technological improvements that will lead to cost reductions in renewable energy, making alternatives to fossil fuel more appealing (Mazzucato and Perez, 2015; Krueger et al., 2020).

At the same time, banks face new risks in this respect, in particular physical and transition risks.[4] Physical risks arise from weather and climate-related catastrophes, such as floods, droughts, storms and sea-level rises (Nordhaus, 1977; Stern, 2008; Nordhaus, 2019).[5] These events can damage properties, lower agricultural productivity, and affect human labour and physical assets (Deryugina and Hsiang, 2014; O'Neill et al., 2017). Should this translate into a contraction of firms' profitability and a deterioration of their balance sheets, banks would be negatively affected in terms of asset values, collateral quality and, ultimately, credit risk exposure. In addition, banks suffering large losses could restrict lending, further exacerbating the financial impact of physical risks through a contraction in the lending supply. The nascent literature provides theoretical and empirical evidence that financial institutions should take physical risk into account in their investment decisions. For instance, Addoum et al. (2019) and Pankratz et al. (2019) provide evidence of a negative correlation between firms exposed to extreme temperatures and their corporate earnings. Balvers et al. (2017) show that firms subject to high temperature shocks have higher capital costs. There is evidence that extreme weather events are incorporated into stock and option market prices (Kruttli et al., 2019; Choi et al., 2020).[6]

Transition risks arise from adjustments made towards developing a green economy and depend on the timing and speed of this process. Unanticipated changes in climate policies, regulations, technologies and/or market sentiment could provoke a repricing of the value of bank assets (CISL, 2019; Hong et al., 2019). Consequently, banks exposed to climate-sensitive sectors could be forced to conduct fire sales of carbon-intensive assets, leading to liquidity problems (Pereira da Silva, 2019a). This could also generate uncertainty and procyclicality, ultimately increasing bank market risk (BoE, 2018). Transition risks could also affect bank credit risk if new technologies or changes in consumer behaviour towards "environmentally friendly" sectors lowered carbon-intensive firms' profitability, further increasing their default risk (Krueger et al., 2020).[7] Although transition risks are difficult to quantify, the market valuation of the top US coal producers fell by 95% over the

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4 Another type of risk that is often mentioned is liability risk (Carney, 2015), which consists of the future impact arising when parties who have suffered losses seek compensation from those responsible. For our purposes, these costs are often considered to be part of either transition or physical risks.

5 Physical risks have increased sharply in recent years, rising from USD 10 billion in the 1980s to USD 138 billion in 2017 (computed as annual global weather-related insured losses; Adrian et al., 2020).

6 For an overview of the literature on weather risk, see Dell et al. (2014).

7 Firms' profitability could also be affected by the implementation, for instance, of a carbon tax.

period 2010-2017 highlighting the fact that disruptive changes to technology can cause sharp fluctuations in the valuation of "stranded assets" (Adrian et al., 2020).[8]

In this paper we focus on two climate change policy events to investigate whether European banks have started to change their lending behaviour by distinguishing between more polluting and less polluting firms, possibly anticipating more stringent climate risk-related policies or more severe fluctuations in the asset values of polluting firms.

We examine the first climate change policy event to investigate whether banks changed their lending behaviour following the introduction of COP21. This question leads to two main hypotheses. The first hypothesis is that the Paris Agreement might have encouraged banks to lend even more to more polluting firms. As banks are not directly constrained to lend to any sector in particular, they might have a greater incentive to "cream off" the market of more polluting firms (i.e. by lending more to these firms) while they are still allowed to do so. The idea here is that banks would benefit from a free ride on a negative externality (pollution) even more than in the past, by continuing to lend to more polluting (but potentially more profitable) firms while they can.

According to the second hypothesis, however, COP21 might have had suasion effects on banks, driving them to lend less to polluting firms. While COP21 may not have an immediate effect on banks' exposure to physical risks, it could affect their exposure to transition risks by affecting the profitability and viability of more carbon-intensive firms, which face high transition costs. Firms producing disproportionately high levels of CO_2 emissions may, for example, find themselves exposed to carbon pricing risk and other regulatory interventions introduced to curtail their emissions (Bolton and Kacperczyk, 2020). Transition risks may eventually also be perceived by banks as a systematic risk factor if regulatory interventions to curb emissions apply equally to all emissions (e.g. in the spirit of a carbon tax). Since the exposure of banks' loan portfolios to climate-relevant sectors is large and comparable to their capital base (Battiston et al., 2017), we expect banks to cushion climate shocks by taking them into account and anticipating transition risks. Hence, in this paper, we ask whether, after COP21, banks have started to change their lending behaviour by altering the amount of credit they provide to carbon-intensive companies. In other words, in our first research question we ask if banks have increased (or decreased) their lending to less "climate-damaging" firms.

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8 Stranded assets are assets such as coal, gas and oil reserves which should remain unused or unextracted in order to keep global warming below the target of 2°C. As such, they may suffer from sudden write-downs, devaluations or conversion to liabilities.

We examine a second climate change policy event to investigate whether European banks changed their lending behaviour towards polluting US firms following Donald Trump's announcement that the United States was withdrawing from COP21 on 1 June 2017.[9] On the one hand, European banks could have interpreted this event as a harbinger of reduced pressure to implement greener policies in the future or, also in this direction, simply concluded that it would be harder to compete with their American counterparts if they restricted the set of investment opportunities to greener companies.

On the other hand, they could have interpreted the announcement as increasing the uncertainty surrounding the path of US climate policy actions, adding a further level of complexity to banks' capacity to manage transition risks. Indeed, this additional uncertainty with regard to the timing and extent of future climate policies may lead to the mispricing of assets and price volatility (Petkov et al., 2015; HSBC, 2015). Moreover, it adds to trade tensions between countries that uphold climate commitments and those that do not. Indeed, in a letter to President Trump on 10 May 2017, the CEOs of some of the largest US corporations recognised that: "…there is strong potential for negative trade implications if the United States exits from the Paris Agreement".[10,11] In addition to transition risks, European banks may also face increased reputational risks if they keep their lending to US polluting corporations unchanged. As public awareness of climate change grows, misalignments between banks' lending decisions and public pressure in favour of a greener economy may taint banks' reputations.[12] Consequently, as a second research question, we investigated whether European banks are anticipating (or not) these plausible risks by modifying the "climate intensity" of their loan portfolio to US firms, i.e. by switching away from more polluting US firms.

To this end, we matched granular information on euro area banks' large exposures to individual counterparties – taken from supervisory reporting – to firm-level greenhouse gas emission intensities. We ran loan-level difference-in-differences and triple-differences estimations over the period 2014-2018. We find that banks reallocated their credit *away* from polluting corporations following both COP21 and President Trump's announcement. Specifically, banks' loan share to the

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9 The official speech is available at https://www.whitehouse.gov/briefings-statements/statement-president-trump-paris-climate-accord/

10 Available at https://theconversation.com/why-trumps-decision-to-leave-paris-accord-hurts-the-us-and-the-world-78707

11 In this regard, the French government has already opposed any trade negotiations between the EU and countries outside the Paris Agreement (including the United States) (Reuters, 2019).

12 Managing reputational risks requires skills such as prudence, anticipating needs and trends, and understanding stakeholders' and customers' needs (Rayner, 2004).

more polluting firms decreases by about 3 percentage points compared with the less polluting (or "greenest") firms after COP21. We show that this result is stronger for banks that are well capitalised, have lower credit quality and are less profitable. Moreover, banks' lending share to polluting US firms fell by about 2.3 percentage points following President Trump's announcement that the United States was withdrawing from COP21. Our results are robust to the inclusion of bank and firm-specific characteristics and are saturated with industry, bank and country fixed effects.

We contend that recent climate change initiatives, as well as an improved awareness of climate change-related risks, are pushing banks towards greener businesses. This shift in behaviour may be driven by increased awareness and encouraged by the unpredictability of both physical and transition risks, which are neither reflected in past data nor captured by backward-looking probabilistic risk management models (e.g. Value at Risk). This uncertainty is driving financial institutions to take early action on climate by curtailing lending to the more polluting firms which – if delayed – could lead to major damage or outright catastrophe (Pindyck, 2020). Finally, although some banks may only perceive a weak direct impact from climate change, as its effects are distributed over a long-term horizon, they appear to be aware that the horizon of regulators and financial agents is much shorter (Bolton et al., 2020). Once rating agencies and/or central banks include climate change in their credit risk assessments or conduct regular climate stress tests, unprepared banks might face additional costs.

This paper has important policy implications in terms of financial stability and the intermediation role that will be played by the banking sector going forward. The International Monetary Fund recognises that there are "massive financial stability challenges due to climate change…" (Adrian et al., 2020, p. 45) as adjustments to a low-carbon economy are uncertain, non-linear and irreversible. In addition, they affect a broad range of sectors, geographies and business models. Financially disruptive events ("green swans") – coming from adverse global warming scenarios or a rapid transition to a low-carbon economy – could be behind the next financial crisis (Bolton et al., 2020). Consequently, the banking sector is facing strong incentives to anticipate climate risks by reallocating its lending in a more sustainable way as "there is a high degree of certainty that some combination of physical and transition risks will materialise in the future" (NGFS, 2019a, p4). These incentives are cushioned in homogeneous and concentrated banking systems, where potential banking barriers to investment in green firms – which threaten the value of legacy contracts – are more likely to materialise (Degryse et al., 2020).

This paper contributes to the still scant literature in several ways. A recent body of research supports the view that financial institutions take both physical and transition risks into account. Goss and Roberts (2011) find that banks charge higher loan spreads to firms that have below-average levels of corporate social responsibility. Chava (2014) shows that lenders charge significantly higher interest rates to firms that create environmental concerns. In addition, fewer banks participate in syndicated lending if corporations have experienced environmental issues. Kleimeier and Viehs (2016) investigated the effect of voluntary disclosures of carbon emissions, finding that more transparent firms face lower loan spreads than non-disclosing firms. Bernstein et al. (2019) find that homes exposed to sea-level rises sell for approximately 7% less that equivalent houses equidistant from the beach. Similarly, Baldauf et al. (2020) show that differences in beliefs surrounding climate change significantly affect house prices. Houses that are projected to be underwater in believer neighbourhoods due to sea-level rises sell at a discount. By investigating the effect of climate change on underwriting fees and initial yields on municipal bonds, Painter (2020) reports that countries that are less likely to be affected by climate change pay lower underwriting fees and yields in order to issue long-term municipal bonds than countries that are likely to be affected. In a recent survey conducted by Krueger et al. (2020), 50% of financial institutions state that – despite the potential horizon uncertainty –climate risks related to new regulations have already started to materialise while only 10% believe that climate risks will materialise in ten years or more. We contribute to the aforementioned literature, which is mostly based on loan pricing and sea-level rise effects on real estate, by focusing on lending reallocation between more and less polluting corporations.

Second, we contribute to the literature that analyses the effect of COP21 on the banking sector's lending decisions. De Greiff et al. (2018) and Degryse et al. (2020) analysed the effect of climate risks on pricing in the syndicated loan market. The former show that since COP21 banks have charged a premium for climate risk which, they argue, is driven by an increased awareness of climate policy-related risks. Degryse et al. show that green firms (i.e. firms with greater environmental consciousness) borrow at significantly lower prices, especially when the lender is also classified as green, and that the results have only become significant since COP21. Similarly, Delis et al. (2018) studied the risks stemming from stranded fossil fuel reserves. They suggest that, after 2015, banks started to price in climate policy exposure by raising the cost of credit for fossil fuel-based firms, determined (again) by an increased awareness of transition risks. By looking at the performance of high-emission industries in the S&P 500 before and after COP21, Ilhan et al. (2018) show that investors already incorporate information on climate-related risks when assessing risk profiles. Ginglinger and Moreau (2020) report that, after COP21, French corporations subjected to greater climate risks reduced their leverage. In line with the aforementioned studies, we focused on the effect of COP21. However, we differed from these studies in that we employed loan-level large exposure data which, granted to large corporations, suit the purpose very well. In this way we are able to match firm-level CO_2 emission intensities to loan-level data. Moreover, we considered an additional policy "shock" (President Trump's announcement of withdrawal from COP21) which allowed us to better interpret possible patterns in banks' lending decisions across climate-related policies.

Our paper is closest to the work of De Haas and Popov (2019) and Mesonnier (2019). De Haas and Popov studied the relationship between the structure of financial systems (measured as the share of stock market financing of total financing through credit and stock markets) and CO_2 emissions. They find evidence of lower CO_2 emissions in economies that are relatively more equity-funded and they argue that stock markets contribute to a reallocation of investment towards less polluting sectors. We complement their paper, which focuses on the stock market, by investigating the bank credit market and we find evidence of similar behaviour (i.e. a reallocation of credit towards less polluting activities). Furthermore, by exploiting the granularity of our datasets, we are able to distinguish between polluting and clean activities at firm-level rather than at industry-level, thereby improving identification. Mesonnier investigates whether French banks reallocated credit from more to less carbon-intensive sectors over the period 2010-2017. In his sectoral assessment, the author finds robust evidence of French banks reducing credit provision to fossil-based sectors. We complement this paper by first augmenting the use of sectoral information with the pollution propensities of individual firms, which is useful as pollution also depends on the production processes and technologies employed by each firm. Second, we also consider firm dynamics over time using firm-level CO_2 emission intensities and loan-level credit exposures, which enhances the granularity of the assessment. We expand on Mesonnier's (2019) sample, which was based on a single country, exploiting a multi-country setting of loans granted by European banks, both in Europe and the United States.[13]

The paper proceeds as follow. Section 2 introduces our methodology, Section 3 the data and Section 4 the results, while several robustness checks are presented in Section 5. Section 6 offers a conclusion.

[13] The ECB's Financial Stability Report (May 2020, Box 3) shows different findings, using sectoral and firm-level approaches. This vouches for the usefulness of firm-level information when analysing banks' exposures in a climate context, particularly for large firms – those more prevalent in our dataset.

2. Methodology

In order to ascertain whether European banks reallocated their lending from more to less polluting firms following COP21 and President's Trump announcement we employ loan-level DiD and triple-differences estimates.

To investigate our first research question, our baseline regression takes the following form:

$$Y_{ijt} = \alpha_i + \tau_k + \delta_b + \beta_1 \, Polluted_{jt} * Post_t + \beta_2 X_{it} + \beta_3 Z_{jt} + \varepsilon_{ijt} \qquad [1]$$

Where reporting banks are denoted by *i*, borrowing firms by *j*, country of a borrowing firm by *b*, corporate sector by *k* and time by *t*. Y defines our dependent variable (loan share) which is computed as the share of the bank's total lending to a specific firm. *Polluted* is a dummy variable which takes the value 1 if a firm is polluting, otherwise 0. Specifically, polluting firms are those firms which have an above-median level of CO_2 emissions, where the median level is 2,093,000 tonnes of CO_2 per year.[14] *Post* is a dummy which takes the value 1 after the introduction of COP21, otherwise 0.[15] β_1 is our coefficient of interest as it represents the average difference in a bank's loan share between more and less polluting firms after the introduction of COP21. X and Z are vectors of the bank and firm-specific control variables we use to capture cross-bank and cross-firm heterogeneity over time which can affect bank lending (see the next section for a more detailed explanation). As bank-specific variables we employ the logarithm of bank total assets (Size), the ratio of equity to total assets (E/TA), the non-performing loans ratio (NPLs), the ratio of fees and commissions income to operating income (Business model) and the ratio of cash and cash equivalents to total assets (Liquidity). We also include the logarithm of firm total assets (Firm Size), the ratio of long-term debt to total assets (LTD/TA), the current ratio (Firm Liquidity), the return on equity (Firm ROE) and the interest coverage ratio (INTcover).[16] Robust standard errors are double-clustered at the bank and the firm level (Behn et al., 2016; Jiménez et al., 2017) which means that we allow standard errors to be correlated within bank-firm pairs but not across them.[17] To tighten the identification, we also include bank fixed effects (α) to control for unobservable bank-specific factors. We also employ sector fixed effects (τ) and country fixed effects (δ) to take unobservable heterogeneity into account across sectors and countries.

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14 Further specifications will be provided in the robustness check section.

15 As the Paris Agreement was signed in December 2015, the Post dummy takes the value 0 for the years 2014 and 2015 and the value 1 for the years 2016, 2017 and 2018.

16 A more detailed definition of the variables employed is provided in Table A1 in the Appendix.

17 We tested the control variables for multicollinearity using the Variance Inflation Factor (VIF). A mean VIF of 1.05 suggests that our controls are not highly correlated (a correlation matrix is provided in Table A2 in the appendix).

To investigate our second research question, we considered an alternative econometric specification where we employed triple-difference interaction terms. The econometric equation takes the following form:

$$Y_{ijt} = \alpha_i + \tau_k + \beta_1 \, Polluted_{jt} * Post\ Trump_t * US\ firms + \beta_2 X_{it} + \beta_3 Z_{jt} + \varepsilon_{ijt} \qquad [2]$$

where *Post Trump* and *US firms* are the only variables that differ from equation [1]. Specifically, $Post\ Trump$ is a dummy variable that takes the value 1 after Trump's announcement to withdraw from COP21 in June 2017, otherwise 0. *US firms* is a dummy variable that takes the value 1 if a firm is headquartered in the US, otherwise 0.

Difference-in-differences estimators require several assumptions to hold. First, treatment assignment has to be exogenous to bank lending. In other words, the policy action ("intervention") should affect bank lending – not the other way round. It is reasonable to expect this assumption to hold in our econometric set up as neither COP21 nor President Trump's announcement are driven by bank lending concerns – they are driven by the potential negative effects of global warming on economies and societies. Second, according to Bertrand et al. (2004) and Imbens and Wooldridge (2009), the DiD approach is only valid under the restrictive assumption (the "parallel trend assumption") whereby changes in the outcome variable over time would be exactly the same in both the treatment (more polluting firms) and the control groups (less polluting firms). Chart 4 (left-hand graph) depicts banks' loan share from 2014 to 2018 for both more and less polluting firms. Loan share moves in the same direction prior to COP21, indicating that the parallel trend assumption holds. Since the agreement in December 2015, banks' share of lending to more polluting firms has fallen steadily over the sample period, while it has stayed constant for less polluting firms. Moreover, Chart 4 (right-hand graph) shows that the loan share to more polluting US firms decreased markedly after Trump's announcement.

3. Data

To investigate the impact of COP21 and President's Trump announcement on bank lending, we constructed a granular dataset combining confidential supervisory and public data. Information on euro area bank large exposure data to individual counterparties is taken from supervisory reporting (COREP 27-31) which requires banks to report to the SSM detailed information on their large exposures since 2014.[18] Firm-level CO_2 total emissions are taken from Thomson Reuters Eikon. Balance sheet information on reporting institutions is drawn from the ECB supervisory statistics, while the balance sheet data of non-financial corporations are sourced from Amadeus. Our final bank-firm matched sample covers 185 euro area banks and 230 corporations from 13 euro area countries and the United States over the period 2014-2018, leading to a total of 5,193 observations. Table 1 displays the number of banks and firms as well as the number of observations by country, economic sector and pollution dummy, while summary descriptive statistics and t-tests for bank loan shares, other balance sheet variables reported for polluting and for non-polluting firms, prior to and after the introduction of COP21 and President Trump's announcement, are shown in panels A-E of Table 2.

I. Corporate carbon emissions data

CO_2 total emissions are measured in tonnes of CO_2 per year and are reported at firm level. Thompson Reuters Eikon follows the Greenhouse Gas Protocol which sets the standard for measuring firm emissions.[19] It distinguishes between different sources of emissions. Scope 1 emissions refer to direct emissions over a one-year period from sources that are owned or controlled by the company, and include emissions from fossil fuels employed in the production process. Scope 2 emissions stem from the consumption of purchased energy (heat, steam and electricity) sourced upstream from the firm. Although firm-level CO_2 emission intensities are estimated by different data providers (CDP, Trucost, MSCI and Sustainalytics), recent research (Busch et al., 2018) has shown that there is little variation in the emissions data across providers (the correlation for Scope 1 data is, on average, 0.99 while it is 0.98 for Scope 2 data). The median firm in our sample produces 2.092 million tonnes of CO_2 emissions (Scope 1 + Scope 2). In Table 3, we report descriptive statistics on pollution by sector.[20] "Industrial metals and mining", "Electricity" and "Gas, oil and coal" produce, on average, the highest level of CO_2 emissions while "Real estate investment trust", "Media" and "Technology" produce the lowest. Our decision to consider firm-level CO_2 emission intensities instead of sectoral breakdowns is motivated by the significant heterogeneity in the level of pollution across firms within each sector. Table 3 shows that companies belonging to the cleanest sectors display levels of CO_2 emissions that are much higher than the median level of 2.092 million tonnes of CO_2.

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[18] Common Reporting (COREP) is the standardised reporting framework issued by the EBA for CRD reporting. It covers credit risk, market risk, operation risk, own funds and capital adequacy ratios.

[19] See https://ghgprotocol.org

[20] We use the sector classification provided by FTSE Russel which is also used by Thompson Reuters Eikon. More detailed information is available at: https://content.ftserussell.com/sites/default/files/support_document/ICB%20Taxonomy%20overview%20Cut%20Sheet_V03.pdf

II. Large-exposure data

Our loan-level data include large-exposure loans which are collected under the large-exposure regime. Introduced in the EU in 2014, the regime aims to ensure that risks arising from large exposures are kept at bay by limiting the maximum loss a bank can incur in the event of a sudden counterparty failure. According to Article 393 of the Capital Requirements Regulation (CCR), an exposure to a single client or a connected group of clients is considered to be a large exposure when, before the application of credit risk mitigation measures and exemptions, it is equal to or higher than 10% of an institution's eligible capital or has a value equal to or higher than €300 million. Our dataset encompasses detailed information on exposures (e.g. instruments) and reporting entities (e.g. LEI for country and sector), which allows us to link the large-exposure dataset to complementary data sources. The large-exposure templates used in our analysis are reported at the highest level of consolidation and also, for the most relevant group sub-structures, at individual level. Detailed information on banking groups available at the ECB allows us to refine the dataset, allocating exposure to specific group components and eliminating duplicates. Panels A and E of Table 2 present the descriptive statistics for our dependent variable (loan share), reported for more and for less polluting firms before and after COP21, while panel H reports the same statistics before and after President Trump's announcement. As mentioned in Section 2, loan share is computed as the share of the bank's total lending to a specific firm. This allows us to investigate how the allocation of loans by each bank (loan share) between more and less polluting firms changed before and after COP21 and Trump's decision to withdraw from it. A primary inspection of the data shows that the average loan share to more polluting firms decreased from 10.8% to 10.2% after COP21, while it increased by about 0.1 percentage points for less polluting firms. Similarly, after Trump's announcement to withdraw from COP21, loan share to more polluting firms fell, on average, by 0.5%, while it increased by 0.4% for less polluting firms.

III. Bank and firm balance sheet data

Panels B and F of Table 2 show summary descriptive statistics for bank balance sheet data. We include bank size (Size), computed as the logarithm of bank total assets, as large bank lending is generally more insulated from adverse shocks and displays a greater degree of diversification (Gambacorta and Marques-Ibanez, 2011; Jiménez et al., 2014; Popov and Van Horen, 2015). We employ the equity to total assets (E/TA) ratio to control for differences in the level of bank capitalisation. The effect of bank capital on lending is not clear-cut. On the one hand, recent studies (Gobbi and Sette, 2015; Michelangeli and Sette, 2016; Bolton et al., 2016; Gambacorta and Shin, 2018) demonstrate that banks with a larger equity base lend more. On the other hand, we cannot exclude that a weakly capitalised bank could boost lending (specifically risky lending) in order to increase earnings which, if retained, could bolster bank equity (Caleb and Rob, 1999). We proxy bank business models by using the ratio of fee and commission income to operating income (Business model). A higher ratio should indicate greater reliance on non-interest income activities and, consequently, less lending. We also control for the effect of asset quality in banks' loan portfolios by employing the non-performing loans ratio (NPLs) (Altunbas et al., 2012) as banks should be able to insulate themselves from credit supply shocks and reallocate loans according to changes in the economic environment and regulations. Finally, we use the ratio of cash and cash equivalents to total assets (Liquidity) as larger volumes of liquid assets could facilitate the transfer of resources to more profitable or less risky assets (Acharya and Naqvi, 2012).

Panels C and G of Table 2 display summary descriptive statistics for firm balance sheet data. Similarly to Jiménez et al. (2017), we control for a variety of firm-specific factors that can affect demand for bank loans. Specifically, we control for size (Firm Size), measured by the logarithm of firm total assets, solvency which we compute by employing both the ratio of long-term debt to total assets (LTD/TA) and the ratio of earnings before interest and taxes to interest expenses (INTcover), profitability, which we calculate as net income divided by equity (ROE) and liquidity (Current ratio), which is captured by the current ratio – a measure of a firm's ability to cover its short-term obligations with its current assets.

4. Results

This section discusses the empirical results for the loan-level DiD and the triple-difference panel regression analysis based on equations [1] and [2]. Columns 1–5 of Table 4 report the results for the loan-level DiD regression prior to and after COP21, while columns 1–3 of Table 5 report the results of the triple-differences prior to and after President's Trump announcement. All the results are presented with the inclusion of several combinations of fixed effects and control variables.

The first column of Table 4 shows that European banks' loan share to more polluting firms fell by about 3 percentage points in comparison with that to less polluting firms (Polluting*COP21). We progressively tightened the econometric specifications by adding country-fixed effects to bank and industry-fixed effects (column 3). Moreover, we used bank-specific characteristics (column 4) and firm-specific controls (column 5), including time-varying observable factors that could affect the supply of and demand for bank credit. Although slightly smaller in magnitude, the statistical significance is identical to that of the other econometric specifications. With regard to the control variable, we observe a positive coefficient of bank capitalisation (E/TA) on lending (column 4). This result is in line with recent studies (Gobbi and Sette, 2016; Michelangeli and Sette, 2016; Bolton et al., 2016; Gambacorta and Shin, 2018) which show that banks with a larger equity base lend more. In addition, we find that smaller and less leveraged firms represent a higher share of bank lending.

Table 5 displays the results of the triple-differences loan-level estimation of European banks' loan share for more versus less polluting firms before and after President's Trump announcement. The interaction coefficient (Polluting*US firms*Trump) indicates that European banks' loan share for US more polluting corporations decreased by 2.38 percentage points after Trump's decision, in June 2017, not to uphold the climate commitment. Again, as in Table 4, we tightened the econometric specifications by controlling for bank and firm-specific characteristics.

We interpret these results as showing that the recent climate change initiatives, as well as improved awareness of climate change-related risks, are pushing banks towards greening their business out of climate-sensitive sectors in favour of more climate-resilient activities. Carbon-intensive investments may be subject to environmental and regulatory risks which include the risk of stranded assets and the long-term tail risks associated with catastrophes related to global warming (Andersson et al., 2016; Dafermos et al., 2018). Moreover, banks and financial institutions are subject to more intense public scrutiny with regard to the environmental effects of their investment decisions. As suggested by some studies (see, among others, McCahery et al., 2016; Dyck et al., 2018), socially responsible investments are a powerful force in shaping banks' behaviour.

I. Impact of bank characteristics on lending responses to climate policy changes

In this section we split the sample by bank-specific characteristics to investigate whether the heterogeneity of bank capitalisation, credit quality and profitability affects banks' reallocation of credit towards less polluting corporations. For instance, banks with deteriorated credit quality, less capital and low profits may perceive the risks stemming from climate change to be more expensive and, consequently, may be motivated to reallocate credit away from polluting firms. These banks may, in general, have fewer concerns when investing in newer (and greener) business – representing an attempt to "gamble for resurrection". The same logic applies to less well capitalised banks (Dell'Ariccia et al., 2014). In this section, we show that banks with deteriorated credit quality and low profits increased their share of lending to greener firms, while less capitalised banks did not, as the result is not statistically significant. We also find that well capitalised banks decreased their share of lending to polluting companies after COP21. This result is probably attributable to the availability of a "capital space" (i.e. additional capital on top of requirements) allowing banks to include climate risk considerations in their medium-term capital planning and to take corporate social responsibilities into account.

The results are displayed in panels A-F of Table 6.[21] Specifically, in panels A and B of Table 6, we split the sample on the basis of capitalisation by using the common equity tier 1 ratio (CET1) and the median CET1 value to define as "well capitalised" those banks with a CET1 ratio of more than 12.34%. On the one hand, well capitalised banks reallocated their credit away from polluting firms, decreasing the share of lending to polluting firms by 2.69 percentage points after COP21 (the result are statistically significant at the 5% level). On the other hand, the result for less capitalised banks is not statistically significant, suggesting that less capitalised banks have limited room for manoeuvre and/or are assuming greater risks in an attempt to increase earnings, which, if retained, could bolster bank equity, thereby improving soundness (Caleb and Rob, 1999).

Panels C and D show the results based on the sample split by bank credit quality. For this exercise, we employed the ratio of non-performing loans to gross loans (NPL) and split the sample according to the median level, defining as the sub-sample of low credit quality those banks that had an NPL ratio of below 3.06%, with the opposite for the group of high credit quality. As expected, banks with deteriorated credit quality switched their lending to less polluting firms (by 2.47 percentage points, significant at the 5% level). It is less risky for them to abandon existing borrowers in favour of new borrowers, given the already impaired capacity of the former to repay debts. The result is also in line with other studies (see, for instance, Gonzalez, 2005; Kouretas, 2011) which find that higher credit risk negates any increase in taking on new risks.

Finally, panels E and F display the results based on the sample split by bank profitability. We used the return on asset (ROA), measured as net income by total assets, and again split the sample according to the median level, defining as the sub-sample of low profitability those banks with a ROA of below 0.36%, and the opposite for the group of more profitable banks. In line with the previous results, we find that less profitable banks switch from more to less polluting corporations (statistically significant at the 1% level). This indicates that less profitable banks have greater incentives to adjust their lending away from climate riskier corporations. Concerns over corporate social responsibility are combined here with the need to adjust portfolios and to seek more profitable investments in new businesses.

21 We used our sample split only for equation [1], as for equation [2] we have fewer observations.

These results suggest that banks' characteristics play an important role in affecting their decisions to incorporate climate risk considerations into their investment choices and to assume the related social responsibilities. It also helps in understanding our baseline results, which appear to be driven by banks with deteriorated credit quality, low profits and comparably high capital levels.

5. Robustness checks

As a first robustness check, we included a different cut-off for the polluting dummy by considering, instead of the median, the first and the last percentiles. This allowed us to control for non-linearities in the level of CO_2 emissions with regard to bank loan share. Specifically, we labelled as *super green* those firms which have a level of CO_2 emissions which is equal to or less than 398,553 tonnes of CO_2 per year (the first percentile of the CO_2 emissions distribution), and as *strong polluters* those companies which produce CO_2 emissions equal to or more than 12,700,000 tonnes of CO_2 per year (the last percentile of the CO_2 emissions distribution). The base dummy is represented by those firms which lie between the first and the last percentiles (which we labelled as *mid-polluters*). The results displayed in Panel A of Table 7 are particularly interesting as they indicate that, while the share of lending to the more polluting companies decreased in line with the baseline results, the share of lending to the "greenest" companies rose by 4.66 percentage points in comparison with *mid-polluters* after COP21. This finding provides further evidence of the fact that banks have been reallocating their credit away from polluting firms and have been investing increasingly in greener companies since COP21.

As a second robustness check, we used a different computation of the dummy *Polluting* which is, in the baseline regression, based on a crude measure of direct and indirect tonnes of CO_2 emissions at firm level. In this robustness, we included the dummy *Polluting/TA*, dividing CO_2 emissions by firm total assets.[22] Although the correlation coefficient between firm size and greenhouse gas intensities is 0.30, suggesting that the level of CO_2 emissions does not depend strongly on firm size,[23] we controlled for the possibility of size effects in the level of pollution which could affect our results. The results in Panel B of Table 7 discard this hypothesis as both coefficients are negative and statistically significant (at the 5% and 1% level respectively) further validating our baseline findings.

[22] In Table A3 in the Appendix, we report descriptive statistics for CO_2 emissions divided by firm total assets, by sector.

[23] Arguably, this may be due to the characteristics of our sample as we have loan-level large exposure data. Such large loans can only be advanced to large corporations – e.g. the average asset size of the companies in the sample is USD 90 billion.

As a third robustness check, we removed France from the sample. According to Ginglinger and Moreau (2020), Article 173 of France's Law on Energy Transition for Green Growth, which was adopted in August 2015, establishes new climate risk reporting requirements for French credit institutions and investors. It is therefore possible that French banks reallocated their credit away from polluting corporations, not as a consequence of COP21, but rather as a reaction to the new regulation that was adopted in France in the same year (2015) that the Agreement was signed. The results displayed in panel C of Table 7 remain statistically significant and of a magnitude which is in line with the baseline, further corroborating our baseline findings.

As a fourth robustness check, we tried to rule out the possibility that banks' share of lending between more and less polluting firms may have altered prior to the introduction of COP21 – e.g. in anticipation of other climate-related policies/shocks or for some bank-specific reason – thereby invalidating our choice of DiD estimation. We included the introduction of a "fake" COP21 one year prior to the actual event. If the estimated coefficient for the "false" COP21 is not statistically significant, we can be more confident that the baseline coefficient captures a genuine policy shock. Panel D of Table 7 shows that the coefficient of COP21 is still negative, although it is smaller and is not statistically significant, adding further support to the validity of our baseline estimation.

As a final robustness check, we tested whether banks reallocated lending *away* from relatively polluting sectors, i.e. by employing sectoral-level rather than firm-level, information. Specifically, we computed a new dummy labelled *Sec_Pol* which is equal to 1 for polluting sectors ("Retailers", "Automobiles and parts", "Construction and materials", "Chemicals", "Gas, water and multi-utilities", "Oil, gas and coal", "Electricity", "Industrial metals and mining"), and 0 for less polluting sectors. The results are reported in Panel E of Table 7. This shows that banks' share of lending to relatively more polluting sectors decreased after both COP21 and President Trump's Announcement, indicating that European banks had reduced their exposure to more climate-sensitive sectors.

6. Conclusion

In this paper we have investigated the impact of climate change-related policies, e.g. the Paris Agreement (December 2015), on European banks' lending behaviour towards polluting versus non-polluting corporations, and of President Trump's announcement to withdraw from the agreement (June 2017). This topic has been largely unexplored in the literature, which focuses mainly on assessing banks' exposures to climate-related risks and investigating the price dimension of banks' reaction. The volume dimension of banks' reaction remains very scant, and has been analysed only at the sectoral-level for individual countries and under strong assumptions.

We offer robust evidence that European banks' loan share to more polluting firms decreased by about 3 percentage points, in relation to less polluting firms, after the announcement of the Paris Agreement. We complement this result with evidence that European banks' loan share to US more polluting corporations decreased by 2.38 percentage points after President Trump's decision not to uphold the Paris climate commitment. We contend that recent climate change initiatives, improved awareness of climate change-related risks, and the anticipation of more stringent policies, are pushing banks out of climate-sensitive sectors and towards greener business. We also show that banks with lower credit quality, low profits and high capital levels are the drivers behind our main results, as they are reacting earlier and more strongly to climate policy actions.

To the best of our knowledge, our paper is the first to evaluate the impact of climate change-related policies on euro area banks' lending behaviour by employing loan-level data matched to firm-level greenhouse gas emission intensities. It is also the first paper to provide quantitative evidence of euro area banks' reallocation of exposures *away* from polluting firms. Our work has important policy implications, as it underlines the pivotal role of banks in the adoption of significant climate change policies. It follows that green banking regulations could make a significant contribution to ameliorating climate change and, as a consequence, central banks and banking authorities could play a key role in shaping this debate.

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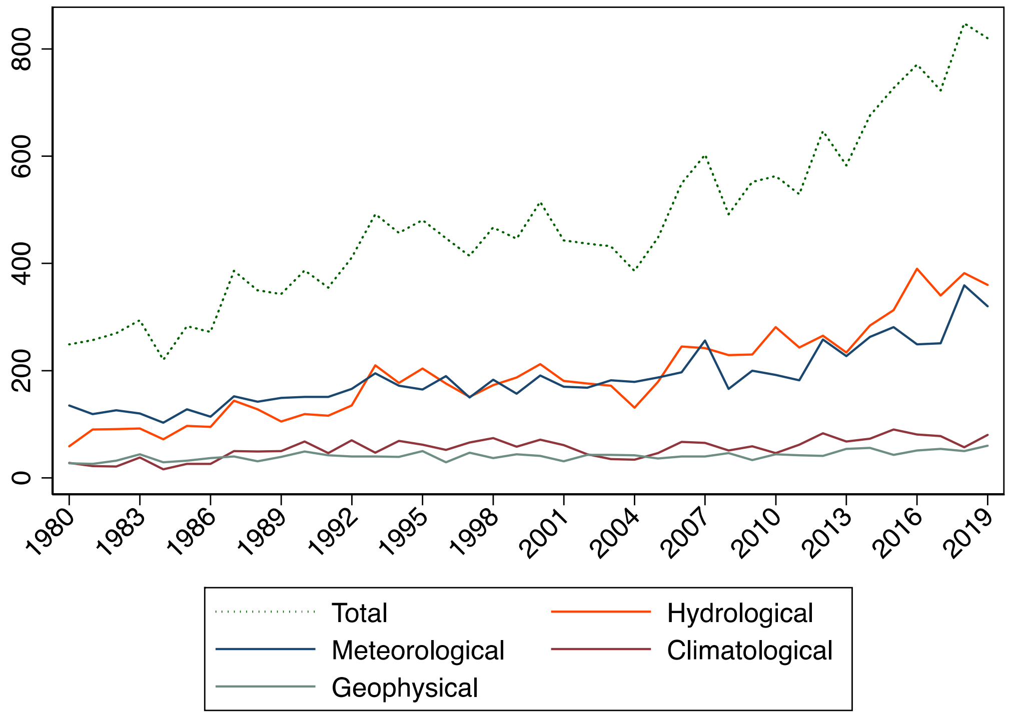
Chart 1

Number of major natural catastrophes worldwide over the period 1980-2019

(number of events; year)

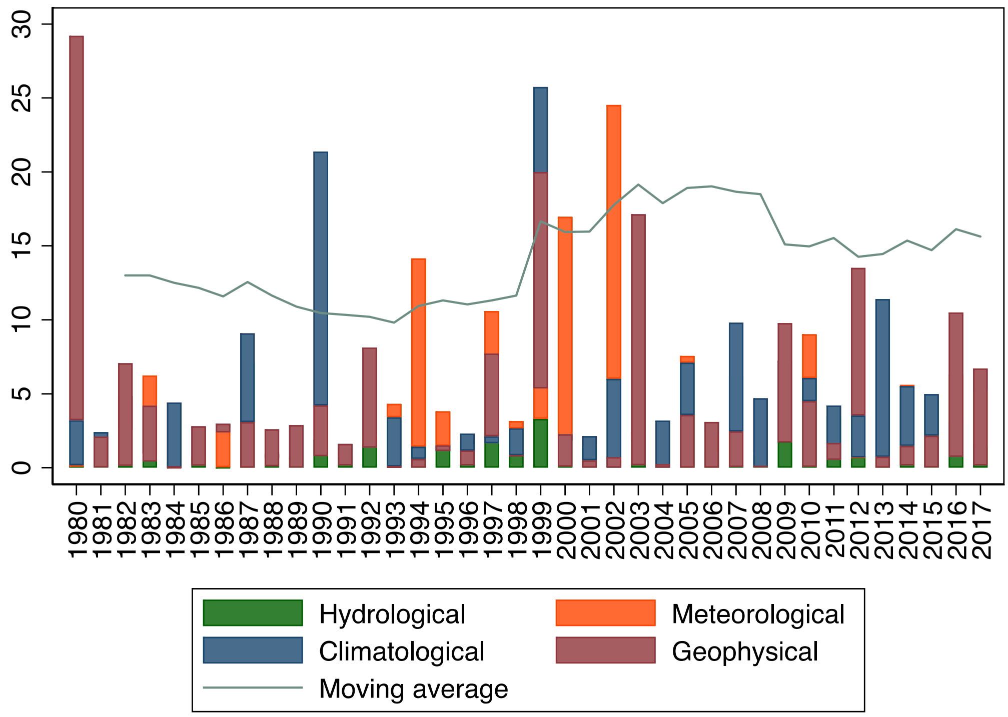


Source: Munich RE (https://www.munichre.com/en/risks/natural-disasters-losses-are-trending-upwards.html).

Chart 2

Economic losses from extreme climate-related events in Europe over the period 1980-2017

(EUR billions, 2017 values)

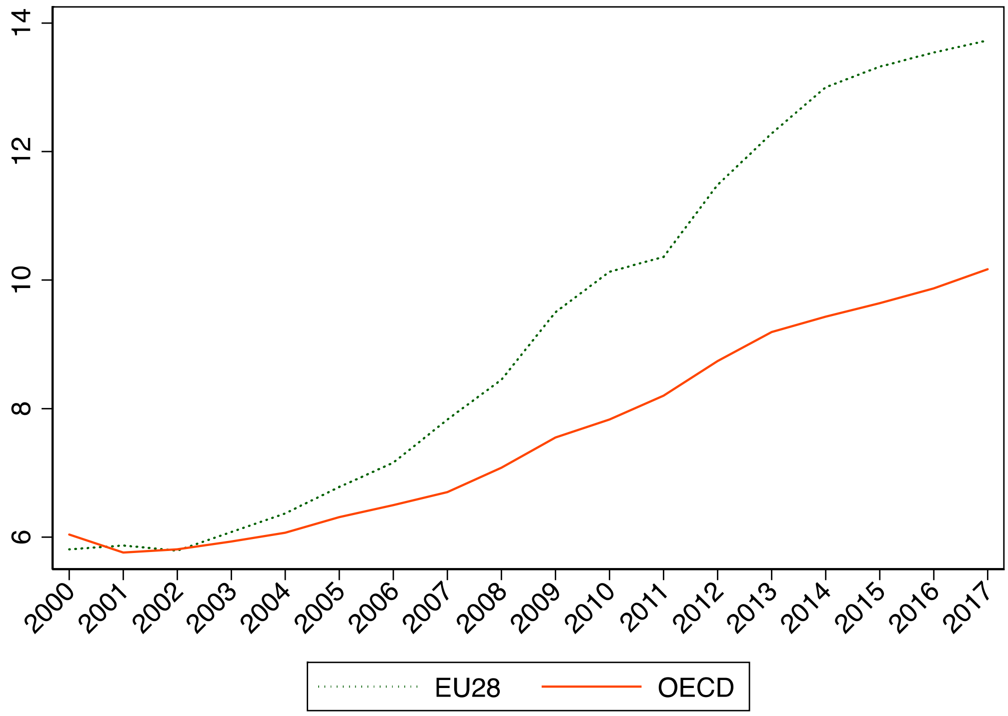


Note**:** The moving average is calculated over a ten-year period. The stacked bars are divided into different segments indicating the economic losses by type of event.
Source: European Environment Agency (https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-3/assessment-2).

Chart 3

Renewable energy as a percentage of total primary energy supply over the period 2000-2017

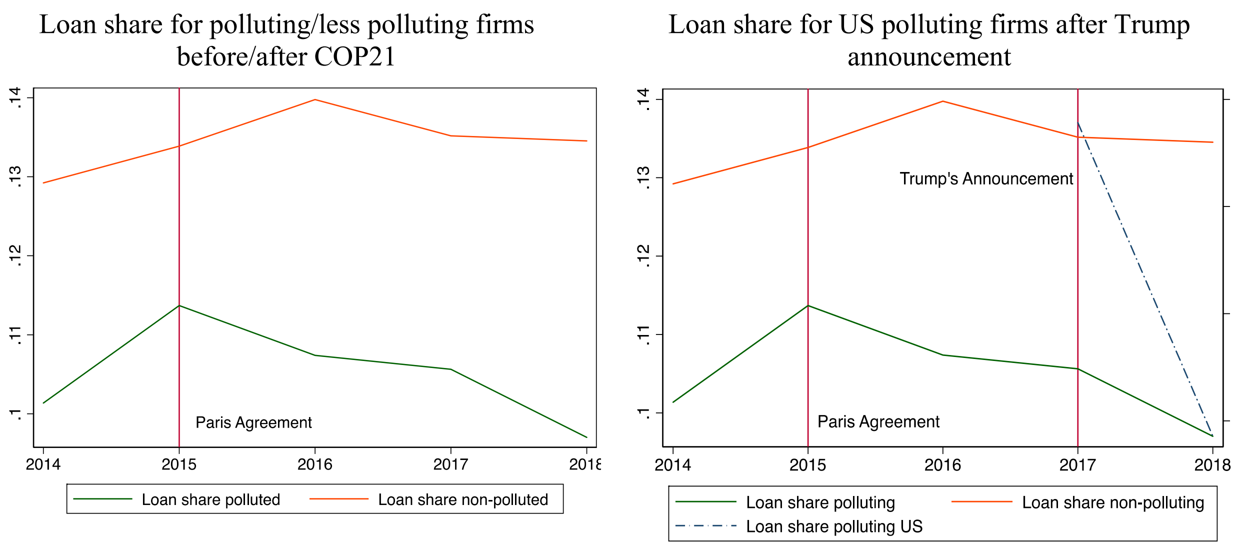
(percentages)



Notes: Renewable energy includes the primary energy of hydro, geothermal, solar, wind, tide and wave sources. Energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases and the renewable fraction of municipal waste are also included.
Source: OECD (https://data.oecd.org/energy/renewable-energy.htm).

Chart 4
Loan share between polluting and less polluting firms over the period 2014-2018

(left-hand scale: average loan share; right-hand scale: average loan share for US polluting firms)



Notes: The dashed-blue line shows the loan share for US polluting firms after President Trump's announcement to withdraw from COP21. Loan share is computed as bank lending to a single firm divided by bank total loans.

Table 1. Number of banks and firms and the number of observations by country, economic sector and pollution dummy

Countries	N.banks (obs.)	N.firms (obs.)	REIT	Media	Tech	Consumer products & services	Healthcare	Tele	Food	Travel	Industrial goods & services	Autos & parts	Retailers	Materials	Chemicals	Utilities	Oil, gas & coal	Electricity	Metals
Austria	8 (16)	6 (56)	2 (10)								1 (12)						1 (12)	1 (12)	1 (10)
Belgium	15 (201)	6 (129)			1 (4)			1 (6)	1 (55)						1 (38)	1 (19)			1 (7)
Germany	22 (875)	30 (738)	3 (38)		1 (17)	2 (41)	1 (70)	1 (30)		1 (11)	6 (110)	4 (172)	1 (17)	1 (13)	2 (65)	1 (33)	1 (5)	3 (65)	2 (51)
Greece	1 (4)	1 (4)						1 (4)											
Finland	7 (29)	5 (50)			1 (16)									2 (14)			1 (5)	1 (15)	
France	59 (1,985)	48 (1,932)	6 (239)	3 (49)	3 (113)	5 (160)	3 (147)	2 (116)	3 (83)	2 (42)	5 (111)	3 (95)	3 (100)	4 (267)		2 (106)	1 (63)	2 (230)	1 (11)
Ireland	1 (32)	0 (0)																	
Italy	24 (627)	9 (421)						1 (90)			2 (45)			1 (6)		3 (60)	1 (107)	1 (113)	
Luxembourg	7 (52)	2 (73)						1 (11)											1 (62)
The Netherlands	15 (557)	8 (84)		1 (21)	1 (5)				1 (15)				1 (7)		2 (11)	1 (10)		1 (15)	
Portugal	7 (147)	6 (100)						1 (6)			1 (7)		1 (7)	1 (5)			1 (16)	1 (59)	
Slovenia	5 (31)	2 (36)						1 (23)			1 (13)								
Spain	14 (636)	10 (429)	1 (22)			1 (10)		1 (76)			2 (89)			1 (72)		1 (15)	1 (26)	2 (119)	
United States		97 (1,141)	1 (6)	3 (29)	18 (218)	4 (36)	16 (128)	5 (62)	5 (79)	1 (5)	10 (171)	3 (55)	7 (65)	3 (40)	5 (48)	4 (88)	4 (37)	5 (52)	3 (22)
Total	185 (5,193)	230 (5,193)	13 (315)	7 (99)	25 (373)	12 (247)	20 (345)	15 (424)	10 (232)	4 (58)	28 (558)	10 (322)	13 (196)	13 (417)	10 (162)	13 (331)	11 (271)	17 (680)	9 (163)
Polluting		99 (2,598)	1 (2)	0 (0)	2 (13)	2 (35)	1 (70)	5 (101)	3 (78)	3 (27)	9 (176)	6 (173)	8 (148)	7 (324)	9 (150)	8 (231)	10 (244)	17 (670)	8 (156)
Non-polluting		148 (2,595)	13 (313)	7 (99)	24 (360)	10 (212)	19 (275)	12 (323)	7 (154)	2 (31)	21 (382)	4 (149)	7 (48)	8 (93)	3 (12)	7 (100)	2 (27)	1 (10)	1 (7)

Notes: “REIT” is a real estate investment trust; “Media” is media; “Tech” is technology; “Consumer products & services” is consumer products & services; “Healthcare” is healthcare; “Tele” is telecommunications; “Food” is food, beverage and tobacco; “Travel” is travel and leisure; “Industrial goods & services” is industrial goods and services; “Autos & parts” is automobile and parts; “Retailers” is retailers; “Materials” is construction and materials; “Chemicals” is chemicals; “Utilities” is gas, water and multi-utilities; “Oil, gas and coal” is oil, gas and coal; “Electricity” is electricity; “Metals” is industrial metals and mining. Observations are reported in parentheses.

Table 2
Summary statistics

	More polluting (=>2,092,000 Tonnes-CO_2/year)									
	Pre-COP21					Post-COP21				
	Obs.	Mean	Std	1st	99th	Obs.	Mean	Std	1st	99th
Panel A. Dependent variable										
Loan share	975	0.108*	0.243	0.000	1.000	1,576	0.102***	0.102	0.00	1.000
Panel B. Bank balance sheet variables										
Size	1,013	26.742***	1.722	21.557	28.271	1,585	26.923	1.512	21.949	28.261
E/TA	1,013	0.073***	0.045	0.055	0.266	1,585	0.068	0.030	0.055	0.179
Business model	1,013	0.404**	0.129	0.122	0.796	1,585	0.421**	0.136	0.117	0.796
NPLs	1,013	0.047**	0.036	0.014	0.139	1,585	0.037	0.027	0.014	0.139
Liquidity	1,013	0.046***	0.030	0.003	0.124	1,585	0.077	0.047	0.005	0.289
Panel C. Firm balance sheet variables										
Firm size	1,013	18.315***	0.953	15.622	20.286	1,585	18.233***	0.960	14.950	19.942
LTD/TA	1,013	0.234***	0.087	0.018	0.453	1,585	0.245	0.079	0.022	0.495
Current ratio	1,013	1.382***	0.640	0.540	3.620	1,585	1.324*	0.565	0.560	3.470
ROE	1,103	8.751***	13.05	-24.94	36.66	1,585	10.731***	14.701	-47.900	39.320
INTcover	1,103	3.562***	3.599	-1.620	15.160	1,585	5.814***	6.190	-4.440	31.160
	US pre-TRUMP					US post-TRUMP				
Panel D. Dependent variable										
Loan share	341	0.046	0.134	0.000	1.000	258	0.041	0.118	0.000	1.000
	Less polluting (=<2,092,000 Tonnes-CO_2/year)									
	Pre-COP21					Post-COP21				
Panel E. Dependent variable										
Loan share	930	0.131*	0.270	0.000	1.000	1,656	0.132***	0.265	0.000	1.000
Panel F. Bank balance sheet variables										
Size	932	27.04***	1.515	22.195	28.271	1,663	26.875	1.572	21.921	28.261
E/TA	932	0.065***	0.026	0.055	0.154	1,663	0.068	0.023	0.055	0.169
Business model	932	0.417**	0.126	0.105	0.694	1,663	0.432**	0.135	0.105	0.796
NPLs	932	0.044**	0.033	0.014	0.139	1,663	0.036	0.025	0.014	0.139
Liquidity	932	0.051***	0.031	0.002	0.122	1,663	0.077	0.046	0.004	0.266
Panel G. Firm balance sheet variables										
Firm size	932	17.055***	1.427	12.649	19.237	1,663	17.199***	1.388	13.058	19.313
LTD/TA	932	0.270***	0.164	0.001	0.768	1,663	0.259	0.146	0.002	0.650
Current ratio	932	1.268***	0.950	0.280	4.770	1,663	1.268**	1.112	0.280	6.890
ROE	932	11.671***	13.668	-37.660	56.370	1,663	13.338***	10.495	-23.290	50.560
INTcover	932	9.083***	19.606	-5.420	124.900	1,663	12.639***	24.502	-5.230	134.150
	US pre-Trump					US post-Trump				
Panel H. Dependent variable										
Loan share	337	0.406	0.150	0.000	1.000	226	0.046	0.136	0.000	0.950

Notes: *Polluting* is a dummy variable that takes a value of 1 if a firm is polluting, otherwise 0. Specifically, polluting firms are those firms which have an above-median level of CO_2 emissions, where the median level is 2,093,000 tonnes of CO_2 per year. Loan share is computed as the share of a bank's total lending to a specific firm. Size is the logarithm of bank total assets. E/TA is the ratio of equity to total assets. Business model is the ratio of fees and commissions to operating income. NPLs is the ratio of non-performing loans to total loans. Liquidity is the ratio of cash and cash equivalents to total assets. Firm size is the logarithm of firm total assets. LTD/TA is the ratio of long-term debt to total assets. Current ratio is the current ratio. ROE is the ratio of net income to total equity. Interest coverage ratio is earnings before interest and taxes divided by interest expenses. T-test of difference in means between the treatment and the control group period and after both COP21 and Trump's announcement is also reported. ***, **, * indicate statistical significance at 1%, 5% and 10% respectively.

Table 3
Summary statistics: CO_2 emissions per year by economic sector (tonnes)

	Sector	N. Obs.	Mean	STD	Min.	Max.
1	Real estate investment trust	215	94,894	236,099	231	2,397,932
2	Media	72	381,992	627,854	12,767	1,925,397
3	Technology	272	893,859	3,445,949	1035	30,200,000
4	Consumer products and services	176	1,285,202	2,193,085	46,854	7,100,000
5	Healthcare	251	1,352,966	1,670,147	4,368	5,540,000
6	Telecommunications	302	1,744,332	2,061,186	11,399	8,801,366
7	Food, beverage and tobacco	162	2,543,849	2,163,238	62	6,180,000
8	Travel and leisure	35	2,545,428	2,256,314	32,415	7,919,844
9	Industrial goods and services	391	3,188,189	7,553,638	16,133	40,300,000
10	Automobiles and parts	200	3,771,219	3,257,347	259	9,510,000
11	Retailers	130	4,280,164	5,471,299	180,436	21,900,000
12	Construction and materials	288	5,207,292	4,880,488	33,940	13,000,000
13	Chemicals	120	20,300,000	10,500,000	309,874	37,400,000
14	Gas, water and multi-utilities	228	25,500,000	41,300,000	290,549	155,000,000
15	Oil, gas and coal	185	39,700,000	28,300,000	26,574	117,000,000
16	Electricity	479	61,500,000	36,800,000	1,349,000	124,000,000
17	Industrial metals and mining	120	85,700,000	85,300,000	633,704	194,000,000

Table 4
Baseline results COP21

	(1) Loan_share	(2) Loan_share	(3) Loan_share	(4) Loan_share	(5) Loan_share
Polluting*COP21	-0.0304***	-0.0259***	-0.0226***	-0.0214***	-0.0223***
	(0.0075)	(0.0062)	(0.0076)	(0.0082)	(0.0075)
Size				0.0249	
				(0.0205)	
E_TA				0.7169**	
				(0.4091)	
Business model				0.0082	
				(0.0708)	
NPLs				0.0952	
				(0.3407)	
Liquidity				-0.0837	
				(0.1058)	
Firm Size					-0.0063**
					(0.0025)
LTD/TA					-0.0153***
					(0.0050)
Current ratio					0.0005
					(0.0023)
ROE					0.0001
					(0.0001)
INTcover					-0.0001
					(0.0001)
Observations	5,105	5,105	5,105	5,105	5,105
R-squared	0.7034	0.7018	0.7049	0.7055	0.7058
Cluster	bank-firm	bank-firm	bank-firm	bank-firm	bank-firm
Industry FE	Yes	No	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes

Notes: Loan share is computed as the share of a bank's total lending to a specific firm. *Polluting* is a dummy variable which takes a value of 1 if a firm is polluting, otherwise 0. Specifically, polluting firms are those that have an above-median level of CO_2 emissions, where the median level is 2,093,000 tonnes of CO_2 per year. *COP21* is a dummy variable which takes a value of 1 after COP21, otherwise 0. Size is the logarithm of bank total assets. E/TA is the ratio of equity to total assets. Business model is the ratio of fees and commissions to operating income. NPLs is the ratio of non-performing loans to total loans. Liquidity is the ratio of cash and cash equivalents to total assets. Firm size is the logarithm of firm total assets. LTD/TA is the ratio of long-term debt to total assets. Current ratio is the current ratio. ROE is the ratio of net income to total equity. Interest coverage ratio is earnings before interest and taxes divided by interest expenses. ***, **, * indicate statistical significance at 1%, 5% and 10% respectively.

Table 5
Baseline results Trump's announcement

	(1)	(2)	(3)
	Loan_share	**Loan_share**	**Loan_share**
Polluting*US firms*Trump	-0.0238***	-0.0239**	-0.0140*
	(0.0083)	(0.0095)	(0.0088)
Size		0.0252	
		(0.0205)	
E_TA		0.7363*	
		(0.4110)	
Business model		0.0233	
		(0.0800)	
NPLs		0.0414	
		(0.3550)	
Liquidity		-0.0818	
		(0.1057)	
Firm size			-0.0062**
			(0.0027)
LTD/TA			-0.0152***
			(0.0050)
Current ratio			0.0008
			(0.0025)
ROE			0.0001
			(0.0001)
INTcover			-0.0001
			(0.0001)
Observations	5,105	5,105	5,105
R-squared	0.7035	0.7049	0.7049
Cluster	bank-firm	bank-firm	bank-firm
Industry FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes

Notes: Loan share is computed as the share of a bank's total lending to a specific firm. Polluting is a dummy variable which takes a value of 1 if a firm is polluting, otherwise 0. Specifically, polluting firms are those that have an above-median level of CO_2 emissions, where the median level is 2,093,000 tonnes of CO_2 per year. *US firms* is a dummy variable which takes a value of 1 if a firm is headquartered in the United States, otherwise 0. *Trump* is a dummy variable which takes a value of 1 after COP21, otherwise 0. Size is the logarithm of bank total assets. E/TA is the ratio of equity to total assets. Business model is the ratio of fees and commissions to operating income. NPLs is the ratio of non-performing loans to total loans. Liquidity is the ratio of cash and cash equivalents to total assets. Firm size is the logarithm of firm total assets. LTD/TA is the ratio of long-term debt to total assets. Current ratio is the current ratio. ROE is the ratio of net income to total equity. Interest coverage ratio is earnings before interest and taxes divided by interest expenses. ***, **, * indicate statistical significance at 1%, 5% and 10% respectively.

Table 6
Results by bank characteristics

	(1) Loan_share	(2) Loan_share
Panel A. Well capitalised		
Polluting*COP21	-0.0269**	
	(0.0136)	
Panel B. Less capitalised		
Polluting*COP21		-0.0072
		(0.0068)
Observations	2,548	2,604
R-squared	0.7035	0.6606
Cluster	bank-firm	bank-firm
Industry FE	Yes	Yes
Bank FE	Yes	Yes
Country FE	Yes	Yes
Firm controls	Yes	Yes
Panel C. High credit quality		
Polluting*COP21	-0.0111	
	(0.0105)	
Panel D. Low credit quality		
Polluting*COP21		-0.0247**
		(0.0118)
Observations	2,544	2,556
R-squared	0.7250	0.7112
Cluster	bank-firm	bank-firm
Industry FE	Yes	Yes
Bank FE	Yes	Yes
Country FE	Yes	Yes
Firm controls	Yes	Yes
Panel E. More profitable		
Polluting*COP21	-0.0042	
	(0.0142)	
Panel F. Less profitable		
Polluting*COP21		-0.0231***
		(0.0086)
Observations	2,503	2,593
R-squared	0.6831	0.7496
Cluster	bank-firm	bank-firm
Industry FE	Yes	Yes
Bank FE	Yes	Yes
Country FE	Yes	Yes
Firm controls	Yes	Yes

Notes: The table is divided into three panels. Panel A displays loan-level difference-in-differences regression results obtained by splitting the sample according to the median level of CET1. Well capitalised banks are those banks with a CET1 of more than 12.34, with the opposite for less capitalised banks. Panel B presents loan-level difference-in-differences regression results obtained by splitting the sample according to the median level of NPL. High credit quality banks are those banks with NPLs below 3.06%, and the opposite for low credit quality banks. Panel C reports loan-level difference-in-differences results obtained by splitting the sample according to the median level of ROA. More profitable banks are those banks with a ROA of more than 0.32 %, with the opposite for less profitable banks. Loan share is computed as the share of the bank's total lending to a specific firm. *Polluting* is a dummy variable which takes a value of 1 if a firm is polluting, otherwise 0. Specifically, polluting firms are those firms which have an above-median level of CO_2 emissions, where the median level is 2,093,000 tonnes of CO_2 per year. *COP21* is a dummy variable which takes a value of 1 after COP21, otherwise 0. ***, **, * indicate statistical significance at 1%, 5% and 10% respectively.

Table 7
Robustness checks

	(1) Loan_share	(2) Loan_share
Panel A. Regression percentiles of CO_2		
Super green*post_PARIS	0.0466***	
	(0.0122)	
Strong polluters*post_PARIS	-0.0278**	
	(0.0116)	
Super green* US firms*Trump		-0.0037
		(0.0286)
Strong polluters*US firms*Trump		-0.0547***
		(0.0196)
Observations	5,137	5,137
Cluster	bank-firm	bank-firm
Industry FE	Yes	Yes
Bank FE	Yes	Yes
Firm controls	Yes	Yes
Panel B. Weighted CO_2 measure		
Polluting/TA*COP21	-0.0124**	
	(0.0061)	
Polluting/TA*US firms*Trump		-0.0635***
		(0.0202)
Observations	5,105	5,105
Cluster	bank-firm	bank-firm
Industry FE	Yes	Yes
Bank FE	Yes	Yes
Country FE	Yes	Yes
Firm controls	Yes	Yes
Panel D. Removing France		
Polluting*COP21	-0.0205**	
	(0.0097)	
Observations	3,199	
Cluster	bank-firm	
Industry FE	Yes	
Bank FE	Yes	
Country FE	Yes	
Firm controls	Yes	
Panel D. Placebo tests		
Polluting*COP21	-0.0052	
	(0.0099)	
Observations	5,105	
Cluster	bank-firm	
Industry FE	Yes	
Bank FE	Yes	
Country FE	Yes	
Firm controls	Yes	
Panel E. Sectoral analysis		
Polluting*COP21	-0.0129**	
	(0.0067)	
Polluting*US*Trump		-0.0132*
		(0.0081)
Observations	5,105	5,105
Cluster	bank-firm	bank-firm
Country FE	Yes	No
Bank FE	Yes	Yes
Firm controls	Yes	Yes

Note: Loan share is computed as the share of a bank's total lending to a specific firm. *Super green* is a dummy that takes a value of 1 if a firm has a level of CO_2 emissions which is equal to or smaller than 398,553 tonnes of CO_2 emissions per year. *Strong polluter* is a dummy that takes a value of 1 if a firm has a level of CO_2 emissions which is equal to or greater than 12,700,000 tonnes of CO_2 emissions per year. *COP21* is a dummy variable which takes a value of 1 after COP21, otherwise 0. Size is the logarithm of bank total assets. E/TA is the ratio of equity to total assets. Business model is the ratio of fees and commissions to operating income. NPLs is the ratio of non-performing loans to total loans. Liquidity is the ratio of cash and cash equivalents to total assets. Firm size is the logarithm of firm total assets. LTD/TA is the ratio of long-term debt to total assets. Current ratio is the current ratio. ROE is the ratio of net income to total equity. Interest coverage ratio is earnings before interest and taxes divided by interest expenses. ***, **, * indicate statistical significance at 1%, 5% and 10% respectively.

Appendix

Table A1
Variable definition

Variables	Source	Description
Dependent variable		
Loan_share	Supervisory reporting (COREP 27-31)	Loan share is computed as bank lending to a single firm divided by bank total loans.
Climate change variables		
CO2 emissions total	Thomson Reuters Eikon	Total CO_2 and CO_2 equivalents emission in tonnes for firm *j and year t*. When a firm reports CO_2 and CO_2 equivalent emissions according to various protocols (i.e. Greenhouse Gas Protocol, Kyoto Protocol, EU Trading Scheme), the Greenhouse Gas Protocol takes priority over the others and is the one reported as a value.
Polluting dummy	Thomson Reuters Eikon and Authors' calculation.	*Polluted* is a dummy variable that takes a value of 1 if a firm *j* is polluting above median level of CO_2 emissions where the median level is 2.092 million tonnes of CO_2 for year *t*, otherwise 0.
Super green dummy	Thomson Reuters Eikon and Authors' calculation.	*Super green* is a dummy that takes a value of 1 if a firm has a level of CO_2 emissions which is equal to or smaller than 398,553 tonnes of CO_2 emissions for firm *j* and year *t*.
Strong polluter dummy	Thomson Reuters Eikon and Authors' calculation.	*Strong polluter* is a dummy that takes a value of 1 if a firm has a level of CO_2 emissions which is equal to or greater than 12,700,000 tonnes of CO_2 emissions for firm *j* and year *t*.
COP21	Author's calculation	*COP21* is a dummy variable which takes a value of 1 for the year 2015, after the Paris Agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse gas emissions mitigation, adaptation and finance, otherwise 0.
Trump dummy	Author's calculation	*Trump* is a dummy variable which takes a value of 1 for the years 2017 and 2018, after President Trump' announcement to withdraw from the Paris Agreement, otherwise 0.
Bank-specific control variables		
Size	Moody's Analytics BankFocus	Bank size is the natural logarithm of total assets (EUR millions) for bank *i* and year *t*.
Capitalisation	Moody's Analytics BankFocus	Capitalisation (E/TA) is the ratio of total equity to total assets for bank *i* and year *t*.
Business model	Moody's Analytics BankFocus	Business model is the ratio of non-interest income (total fees and commissions) to total revenues for bank *i* and year *t*.
NPLs	Moody's Analytics BankFocus	The non-performing loans ratio (NPLs) is the ratio of non-performing loans to total loans for bank *i* and year *t*.
Liquidity	Moody's Analytics BankFocus	Liquidity is the ratio of cash and cash equivalents to total assets for bank *i* and year *t*.

Firm-specific control variables

Firm Size	Thomson Reuters Eikon and Amadeus, Bureau van Dijk	Firm size is the natural logarithm of total assets (EURO millions) for firm *j* and year *t*.
Leverage ratio	Thomson Reuters Eikon and Amadeus, Bureau van Dijk	The leverage ratio (LTD/TA) is calculated by dividing long-term debts by total assets for firm *j* and year *t*.
Current ratio	Thomson Reuters Eikon and Amadeus, Bureau van Dijk	The current ratio is calculated by dividing current assets by current liabilities for firm *j* and year *t*.
ROE	Thomson Reuters Eikon and Amadeus, Bureau van Dijk	The return on equity (ROE) is the ratio of net income to total shareholder's equity for firm *j* and year *t*.
INTcover	Thomson Reuters Eikon and Amadeus, Bureau van Dijk	Interest coverage ratio is calculated by dividing the earnings before interest and taxes by interest expenses for firm *j* and year *t*.

Table A2
Correlation matrix between the variables used in the baseline regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Size		**-0.36**	**0.07**	**-0.12**	**0.21**	**0.11**	**-0.03**	0.02	**0.04**	**0.04**
E/TA	**-0.36**		0.00	**0.21**	**-0.10**	-0.00	-0.04	-0.01	-0.02	**-0.03**
Business model	**0.07**	0.00		**-0.20**	**0.20**	**0.03**	0.00	**-0.06**	-0.00	0.01
NPLs	**-0.12**	**0.21**	**-0.20**		**-0.24**	**-0.08**	0.00	0.00	-0.00	**-0.05**
Liquidity	**0.21**	**-0.10**	**0.20**	**-0.24**		0.08	-0.00	**0.02**	**0.03**	**0.05**
Firm size	**0.11**	-0.00	**0.03**	**-0.08**	0.08		**-0.05**	**-0.10**	-0.02	**-0.07**
LTD/TA	**-0.03**	-0.04	0.00	0.00	-0.00	**-0.05**		**-0.03**	-0.00	**-0.08**
Current ratio	0.02	-0.01	**-0.06**	0.00	**0.02**	**-0.10**	**-0.03**		**-0.02**	**0.07**
ROE	**0.04**	-0.02	-0.00	-0.00	**0.03**	-0.02	-0.00	**-0.02**		**0.16**
INTcover	**0.04**	**-0.03**	0.01	**-0.05**	**0.05**	**-0.07**	**-0.08**	**0.07**	**0.16**	

Notes: Correlations that are significant at (at least) the 5% level are reported using bold italics. The number on the horizontal axis indicates the variables on the vertical axis – each number matches the variable's position on the vertical axis. Size is the logarithm of bank total assets. E/TA is the ratio of equity to total assets. Business model is the ratio of fees and commissions to operating income. NPLs is the ratio of non-performing loans to total loans. Liquidity is the ratio of cash and cash equivalents to total assets. Firm size is the logarithm of firm total assets. LTD/TA is the ratio of long-term debt to total assets. Current ratio is the current ratio. ROE is the ratio of net income to total equity. Interest coverage ratio is earnings before interest and taxes divided by interest expenses.

Table A3
Summary of descriptive statistics: tonnes of CO_2 emissions to firm total assets by economic sector.

	Sector	N. Obs.	Mean	STD	Min.	Max.
1	Media	99	0.008	0.009	0.001	0.049
2	Real estate investment trust	315	0.012	0.041	0.000	0.264
3	Healthcare	345	0.021	0.203	0.000	0.102
4	Telecommunications	424	0.024	0.040	0.001	0.385
5	Automobiles and parts	322	0.024	0.026	0.000	0.164
6	Food, beverage and tobacco	232	0.033	0.022	0.000	0.090
7	Consumer products and services	247	0.043	0.077	0.001	0.439
8	Retailers	196	0.061	0.055	0.002	0.380
9	Industrial goods and services	558	0.086	0.240	0.002	1.938
10	Technology	373	0.129	1.015	0.000	9.295
11	Construction and materials	417	0.165	0.206	0.013	1.424
12	Travel and leisure	58	0.234	0.173	0.019	0.724
13	Chemicals	162	0.397	0.204	0.003	0.858
14	Gas, water and multi-utilities	331	0.480	0.572	0.007	2.002
15	Electricity	680	0.491	0.306	0.097	2.086
16	Oil, gas and coal	271	0.936	5.356	0.004	6.171
17	Industrial metals and mining	163	1.340	0.932	0.049	2.741

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